

Substituting into the equilibrium expression we get

$$0.42 = \frac{(s)(s)}{(0.010)^4}$$

$$s^2 = 4.2 \times 10^{-9}$$

$$s = 6.5 \times 10^{-5} \text{ M}$$

You can see that not all complex ion formation leads to increased solubility. The molar solubility of CdC_2O_4 in water is 1.2×10^{-4} .

- b. Determine the molar solubility of CdC_2O_4 in 5.0 M NH_3 and compare with the solubility obtained above with 0.010 M NH_3 . (E12)

- c. How many grams of AgBr can be dissolved in 1.0 L of 2.5 M NH_3 ? AgBr in NH_3 forms $\text{Ag}(\text{NH}_3)_2^+$. Compare with the mass of AgBr that can be dissolved in 1.0 L of pure water. (E13)

SELF-TEST

A. Multiple Choice:

- The solubility product constant K_{sp} of Ag_2CrO_4 is related to its solubility in water as $K_{\text{sp}} =$
 - s^2
 - s^3
 - $4s^3$
 - s
 - none of those
- The solubility product expression for $\text{Zn}(\text{CN})_2$ is
 - $[\text{Zn}^{2+}][\text{CN}_2^-]$
 - $[\text{Zn}^{2+}][\text{CN}^-]^2$
 - $[\text{Zn}^{2+}][2 \text{CN}^-]$
 - $[\text{Zn}^{2+}][2 \text{CN}^-]^2$
- In which of the solutions listed below is AgCl least soluble?
 - pure water
 - 0.20 M CaCl_2
 - 0.20 M AgNO_3
 - 0.20 M NaCl

4. Which carbonate would be the first to precipitate from a solution of 0.1 M in metal cation as CO_3^{2-} is added?
- | | | | |
|--------------------|---|--------------------|--|
| a. BaCO_3 | $(K_{\text{sp}} = 2.6 \times 10^{-9})$ | b. CaCO_3 | $(K_{\text{sp}} = 4.9 \times 10^{-9})$ |
| c. FeCO_3 | $(K_{\text{sp}} = 3.1 \times 10^{-11})$ | d. MgCO_3 | $(K_{\text{sp}} = 4 \times 10^{-6})$ |
5. Addition of an aqueous solution of KCN to an aqueous solution of NiCl_2 results in the formation of a solid which dissolves upon addition of more KCN (aq). Which of the following statements is the most probable explanation for these observations?
- Ni^{2+} forms $\text{Ni}(\text{CN})_2$ (s) and then forms $\text{Ni}(\text{CN})_4^{2-}$.
 - KCl (s) is formed then reacts with additional CN^- to give ClCN (aq).
 - $\text{Ni}(\text{OH})_2$ (s) forms and then dissolves as $\text{KNi}(\text{OH})_3$.
 - $\text{Ni}(\text{CN})_2$ (s) forms but goes back into solution because addition of KCN makes the resulting solution more dilute and hence unsaturated.
 - none of these

B. True or False:

What happens when 50.0 mL of 0.050 M BaCl_2 is added to 50.0 mL of 0.10 M K_2SO_4 ?

- _____ 1. KCl will precipitate.
- _____ 2. The initial concentration of Ba^{2+} , $[\text{Ba}^{2+}]_0 = 0.025$ M after the two solutions are mixed, but before reaction occurs.
- _____ 3. If $[\text{Ba}^{2+}]_0 \times [\text{SO}_4^{2-}]_0 > [\text{Ba}^{2+}]_{\text{eq}} \times [\text{SO}_4^{2-}]_{\text{eq}}$, then precipitation occurs.
- _____ 4. $[\text{Cl}^-]_{\text{eq}} = [\text{K}^+]_{\text{eq}} = 5.0 \times 10^{-2}$ M

Consider PbCl_2 . When it dissolves, the following reaction takes place.



- _____ 5. PbCl_2 can be dissolved by a strong acid.
- _____ 6. PbCl_2 can be at least partially dissolved by a strong base if $\text{Pb}(\text{OH})_4^{2-}$ exists.
- _____ 7. It is easier to dissolve PbCl_2 at higher temperatures.
- _____ 8. The molar solubility of PbCl_2 (s) in pure water can be expressed as $2s^3$.

C. Fill in the blanks:

Consider a saturated solution of $M(OH)_2$ where M^{2+} is a metal cation. Dissolving $M(OH)_2$ in water is an endothermic process. On the blanks provided, write **P** if a precipitate forms and **NP** if no precipitate forms when the saturated solution is subjected to:

- _____ 1. The addition of MCl_2 solution where M^{2+} is the same metal cation
- _____ 2. The addition of HCl
- _____ 3. An increase in temperature
- _____ 4. The addition of water
- _____ 5. The addition of ammonia to form $M(NH_3)_4^{2+}$

D. Problems:

Consider manganese sulfide, MnS , and tin(II) sulfide. Manganese sulfide has a K_{sp} of 5×10^{-14} . The solubility of tin(II) sulfide is 2×10^{-14} mol/L.

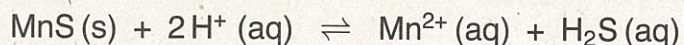
- 1. Calculate the K_{sp} of tin(II) sulfide.
- 2. How many milligrams of MnS can be dissolved in enough water to make 10.0 L of solution?

3. Calculate $[S^{2-}]$ if $[Mn^{2+}]$ is 2×10^{-5} .

4. Will a precipitate form if 0.500 mol of Mn^{2+} are added to one liter of a solution containing 0.0010 mol of S^{2-} ions?

5. In a solution that contains 1.00×10^{-4} mol of Mn^{2+} and 1.00×10^{-4} mol of Sn^{2+} , which will precipitate first when 1.00×10^{-10} mol S^{2-} is added?

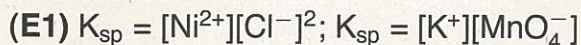
6. Calculate the molar solubility of MnS in 0.3 M H^+ and 0.2 M H_2S . Assume that for the reaction



K is 5×10^6 .

Consider copper. The K_{sp} for CuCl is 1.7×10^{-7} . The K_f for CuCl_2^- is 1×10^5 .

7. Write the equation for the reaction between a solution of CuNO_3 and NaCl where a precipitate of CuCl is obtained.
8. At what concentration of NaCl will precipitation occur if NaCl is added to a 0.10 M solution of CuNO_3 ?
9. Write the equation for the formation of CuCl_2^- from the reaction between CuCl and additional aqueous NaCl .
10. What is K for the reaction in (9)?
11. Compare the molar solubility of CuCl in pure water to that in aqueous 2.0 M NaCl where CuCl_2^- is formed.

ANSWERS**Exercises:**

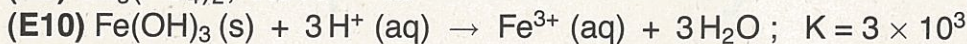
(E2) 9.0×10^{-5}

(E3) $[\text{OH}^-] < 4 \times 10^{-5} \text{ M}$ gives an unsaturated solution(E4) yes, $\text{Ca}_3(\text{PO}_4)_2$ $[\text{OH}^-] = 4 \times 10^{-5} \text{ M}$ gives a saturated solution $[\text{OH}^-] > 4 \times 10^{-5} \text{ M}$ gives a supersaturated solution(E5) $6.7 \times 10^{-3} \text{ M}$; BaF_2 first

(E6) 9.6×10^{-9}

(E7) 2 mg

(E8) 0.0019 g/L; 0.74 g/L

(E9) $\text{Ca}_3(\text{PO}_4)_2$; $4 \times 10^{-11} \text{ M}$ (E11) $5 \times 10^6 \text{ M}$

(E12) 16 M

(E13) 1 g in NH_3 ; 0.1 mg ($1 \times 10^{-4} \text{ g}$ in water)**Self-Test****A. Multiple Choice:**

1. c

2. b

3. b

4. c

5. a

B. True or False:

1. F

2. T

3. T

4. F

5. F

6. T

7. T

8. F

C. Fill in the Blanks:

1. P

2. NP

3. NP

4. NP

5. NP

D. Problems:

1. 4×10^{-28}

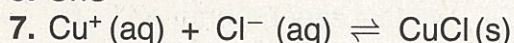
2. 0.2 mg

3. 3×10^{-9}

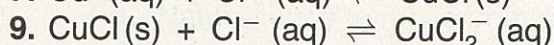
4. yes

5. SnS

6. $2 \times 10^6 \text{ M}$



8. $1.7 \times 10^{-6} \text{ M}$



10. 2×10^{-2}

11. in pure water: $4.1 \times 10^{-4} \text{ M}$ in 2.0 M Cl^- : $4 \times 10^{-2} \text{ M}$